

## SOME PROBLEMS IN SMALL ARMS MANUFACTURE

*Paper presented to the Institution, Sydney (New South  
Wales) Section by J. Finlay, M.I.P.E.*

The problems dealt with in this paper include the control of gauge making by proper allocation of tolerances for wear and manufacture, the tolerances allowable for various machining operations, the determination of limits for material specifications, jig design, and rifle boring and straightening. The honing of rifle bores and checking by auto-collimator are also mentioned.

IT is proposed to set forth briefly some of the problems we encounter in the manufacture of small arms in this country.

As all the designs of the various weapons are finalised overseas, we are thus furnished with specification drawings showing the measurements of the components, the tolerances allowed, and the specifications for the materials. In a particular case there may be about 200 drawings covering the components and their assemblies, but by the time all the drawings for cutting tools, gauges, and fixtures have been made the total number of drawings will run into thousands. Almost every operation on any component requires at least one drawing for the jig or fixture, one for the layout operation, one or more for the tools, one or more for working, examination, inspection, and check gauges. For the various weapons in manufacture we find that there are respectively 10,000, 20,000, and 18,000 drawings. A surprising amount of detail work is required in looking after and indexing these drawings. Then, when new drawings of components, showing amendments are received, every drawing connected with these amendments has to be gone through and the necessary alterations made. If the departments who propose these amendments or alterations realised the amount of work entailed, then perhaps they would hesitate and consider not only the alterations to drawings but the attendant alterations to tools, fixtures, and gauges.

The type of operation sheet used is shown in Fig. 1. This is a copy of that used at the Royal Small Arms factory at Enfield, and it will be noted that all the information necessary is shown, such as the machine used, number of fixtures, tools, and gauges, where component is located, where machining takes place and the limits allowed.

# THE INSTITUTION OF PRODUCTION ENGINEERS

It is only in the last few years that a system of tolerances on gauges has been introduced, and this has resulted in a saving of cost in their manufacture. Previously gauge drawings had only the bare dimensions and consequently a certain understanding had more or less to be established between the toolroom and the gauge department as to what would be accepted. This system was costly and led to much spoiled work. Now with the tolerances as adopted, each tool maker knows that limits allowed on the various gauges and

## OPERATION DETAIL

STORE Gun m/c. Bren COMP. Stop, nut barrel. DRG. M.G. detail 1390.  
 .303 in.  
 OP. 5 Cross mill right M/c. No. M/c. P. & W. auto. mill SIZE 5in.  
 side 1st.  
 SPOT ----- CUT /////////////// SPEED FEED

F No. 5896.  
 T No. 9450 std. arbor  $1\frac{1}{4}$  in. d.  
 G No. 12053-5 and 60.  
 PLAN R.S.A.F. DATE  
 CHK. DATE  
 APP. DATE  
 LAB. (Group).  
 ISSUED.

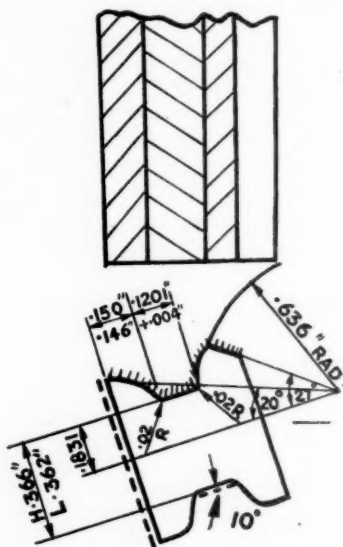


Fig. 1.

as a rule has not much trouble in working to them. This system has cheapened gauge costs by at least 30%. It also allows of gauges being put out for manufacture by outside firms, who know exactly what limits they are expected to work to.

The chart (Fig. 2) shows diagrammatically how the tolerances are allowed. The Royal Small Arms factory, Enfield, has laid down a system whereby not only a tolerance for gauge making, but also a certain amount for wear is allowed on the shop gauges. (Fig. 2).

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When the specification drawing for the component shows a tolerance of .005 in. and over, 20% of the tolerance shown is deducted and used on the "go" size of the gauge as an allowance for wear, and 10% of the remaining tolerance is given as a tolerance for gauge making. When the tolerance is under .005 in., only 10% is deducted and 10% of the remaining tolerance allowed for gauge making.

The upper half of Fig. 2 is a snap gauge. On the top right hand corner is shown the size specified, and at the top left hand corner

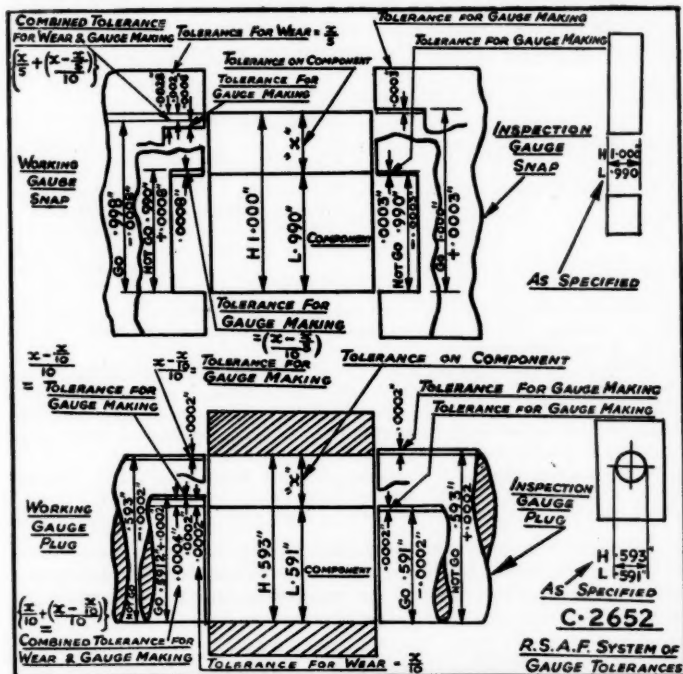


Fig. 2.—System of Gauge Tolerances.

is shown the formula for calculating the combined tolerance for wear and gauge making. X represents the tolerance on the component as specified. The application of this formula is shown on the left hand side of the upper half which represents "go" and "not go" shop gauges. On the right hand side are inspection gauges. It will be seen that no tolerances are allowed for wear on inspection gauges and the tolerance for gauge making is added or subtracted in the opposite way to shop gauges.

The bottom half of Fig. 2 shows the application of the formula for wear and gauge making tolerances of plug gauges. This system applies where two components work together and may be replaced at some subsequent date. The component drawings should generally be so dimensioned, that the high male and low female which mate together have a definite clearance to ensure that such components will always assemble without adjustment. Where very close fitting, or tight fits are required, it may be necessary to depart from this general principle by which inspection gauges may accept work outside the drawing dimensions owing to either the tolerance on the inspection gauges, or wear of the gauges, or both.

The tolerances on inspection gauges have been decided as follows—

		<i>Size of gauge (inches)</i>	<i>Tol. (inch)</i>
Plain plug and ring gauges	...	Up to 0.5.	0.0001
		0.5 to 2.0 inclusive.	0.0002
Gaps and flat plugs	... ..	Up to 1.0.	0.0003
		1.0 and above.	0.00005
			per inch in addition to the 0.0003 above.

Where the tolerance allowed by the component drawing is less than 0.0003 in. the tolerance to be allowed on these gauges is to be one-tenth of the tolerance on the component.

**PROFILE GAUGES.** The error in any one contour not to exceed 0.0015. In over-all length the tolerance to be the same as for gap gauges given above

**RECEIVER GAUGES.** To be treated on their merits. Suitable clearances to be allowed on non-vital points, Multiplying indicator gauges or dial gauges to be used wherever possible.

The tolerances on the above gauges are to be + for "go" rings and gaps — for "go" plugs, — for "no-go" rings and gaps, and + for "no-go" plugs, i.e. inspection gauges must pass all work made to drawing dimensions.

In connection with tolerances allowed on the various components it is desirable that the department responsible for the tolerances should always keep in mind the conditions under which the components have to be manufactured.

Experience in mass production of small arms components has suggested that the following tolerances between the locating points and surfaces being machined are obtainable by the use of unskilled labour.

When surface is formed by	
milling, profiling, slotting, <i>Inch</i>	
or shaving ... ..	.008
With slightly more care ...	.006
With second or finishing operation ... ..	.004

In the cases of sizes dependent upon the dimensions of the cutting tool their tolerances are readily obtainable.

Width of slot formed by mill-	<i>Inch</i>
ing cutter ... ..	.004
If second cut ... ..	.002
If second cut and frequently	
changed ... ..	.001
Diameter of fairly short holes	
if drilled or hollow milled	.004
Single reamed or box tooled	.002

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Surface grinding on large grinder using cup wheel . . . . .	.003	Second reamed or box tooled . . . . .	.001
With more care . . . . .	.002	Second reamed with skill (as for locating holes or for driving fits) . . . . .	.0006
Surface grinding on small grinder using disc wheel . . . . .	.001	Diameter of long holes such as in rifle barrels where several reamings are done . . . . .	.0015
Axial position of fairly short jigged holes . . . . .	.002	Special care with some selection . . . . .	.0006
With refined equipment and skill . . . . .	.0005	Diameter of rifling grooves . . . . .	.003
End of milling or shaving cut if hand fed against stop . . . . .	.004	With special care . . . . .	.0015
Hand fed with skill against special stop . . . . .	.001	When wood work is milled or profiled . . . . .	.010
Position of shoulders or ends of holes dependent upon ordinary spindle stops . . . . .	.015	With slightly more care . . . . .	.005
With greater care . . . . .	.006	Drop cuts for depth . . . . .	.005
Skill with special stops . . . . .	.002	With slightly more care . . . . .	.002
In the case of generated sizes dependent upon the cutting tool being moved to a stop such as turning, boring, and centre grinding, in diameter . . . . .	.006		
With some care, in diameter . . . . .	.004		
With skill and refined equipment, in diameter . . . . .	.002		
Grinding short pieces with skill, in diameter . . . . .	.001		

The above list of tolerances procurable by the various methods should serve as a guide. Special conditions in certain operations may require departures. Experience has shown that, ordinarily, little will be gained by the adoption of tolerances much in excess of those suggested at the larger end of the range.

Too great tolerances breed carelessness in production. On the other hand, costs begin to mount increasingly as the smaller end of the range is specified.

Tolerances for mass production are required because of legitimate variations demanded by the following: (a) Lack of rigidity in machines, even in good condition; (b) spring of cutting tool or arbor; (c) adjustment of cutting tool with respect to position and shape or size of tool; (d) variation due to minute clearance between component locating holes or surfaces and their locating pins or surfaces on machining fixture and gauge; (e) wear on cutting edge of tool.

Other variations caused by undue spring of cutting tool or arbor, improper locating points on components, faulty design of machining fixture or gauge, etc., are not legitimate variations and should be avoided by proper methods and correctly designed equipment. Much time can be very profitably spent on the drawing board by the designs department when setting out the tolerances on the various components, if they will keep in mind the tolerances that can be anticipated for the various machining operations. This is one place

where production engineers can be very usefully employed and the value of their production knowledge used to its fullest advantage.

In specifications for material a great deal of trouble could be saved if someone with the requisite knowledge and authority would state that specifications are to be used as a guide to the class of material required and not to be regarded as unalterable. When drawing up the specifications someone has been obliged to set down figures, but I have yet to be convinced that a lot of preliminary investigation showed the reason for those particular figures. For instance a specifications may state carbon .5 to .6, manganese .6 to .7, but it does not follow that a steel just outside these limits is not suitable provided it complies with the physical tests. Then again, against certain specifications, there are specified certain hardness figures that must be obtained after heat treatment. Very often if the carbon and manganese are on the low side then it is impossible to obtain the hardness figure, which goes to show that the specification was not properly investigated before being issued. It is certainly time that before specifications are issued the responsible authorities should consult the steel manufacturers, setting clearly before them what they expect in the way of hardness, strength, toughness, freedom from distortion, etc. The steel manufacturers have a wealth of experience and knowledge, and these should be utilised to their fullest extent. After all, the steel manufacturers have to make the steel, and it does seem impractical to issue specifications and then find that one cannot obtain steel to that specification that will make satisfactory components.

It is only in the last few years that the designers have taken advantage of the use of alloy steels. We have had the experience of seeing a weapon designed thirty years ago, when carbon steels were specified, being modified and speeded up considerably. These modifications greatly increased the working stresses but the same plain carbon steel were specified for its manufacture and consequently gave trouble in many instances.

One of the material problems is the supply of steel for deep hole drilling such as rifle and machine gun barrels. Much work has been done here in co-operation with the local steel manufactures, and it has been found amongst other things that the elimination of the use of aluminium as a deoxidiser has been very beneficial.

Material is supplied to the machine shops as bar stock or drop forgings. Each individual drop forging or bar is tested on a Gogan hardness testing machine, before issue, to make sure it complies with the specification. This 100% testing has proved its value, for besides checking the material it also precludes the possibility of issuing material that is so hard that it may spoil expensive cutters and thus cause delay in manufacturing. This hardness tester is a regular production machine and the material does not require cleaning or

scaling before testing. Tests can be put through at the rate of several per minute.

Jigs or fixtures are required for almost every operation on each component and there are several points to be watched in their design : (1) They must hold the component satisfactorily and allow of easy ingress and egress ; (2) they must be designed to suit the machine for each particular operation ; (3) they must be designed to permit ease of manufacture ; (4) wearing parts should be readily replaced or repaired ; (5) location faces and places should have ample wearing surfaces.

The failure to use the same set of locating points for all the final machining and position gauging operations on a component is bad practice and its effects are insidious. When more than one set of locating points are used, the unavoidable tolerances between the various sets of locating points themselves may very well result in absorbing the allowed tolerances on the surfaces affected. Good engineering should not waste or absorb any of the permissible tolerances. All of these should be given, as intended, to the actual machining operator.

The design of gauges is closely tied up with design of fixtures in that the locating faces should be identical on both. It is also necessary in some cases to use the same clamping arrangements on both gauge and fixture. In other cases it may be wise to incur additional expense on complicated gauges by using detachable gauging faces which can later be renewed without much expense. Very often the most cheaply designed gauge is more expensive in the long run, when maintenance costs are taken into account. Now that hard chromium plating is available it is well to keep this process in mind when designing gauges, especially for long wear and ease of renewal. It is our practice to have working gauges for use by the manufacturing section and examination gauges for use by the factory viewing department. Inspection gauges are used to view the components in the finished stages. These may be used both by factory view and the inspection department. According to their different requirements, components may be sent to the factory view after various stages of manufacture. In other cases, factory viewers may gauge the work in various departments in the course of manufacture. We have no hard and fast rule in this respect but make the inspection to suit the components being made.

The manufacture of small arms covers the following operations : Drop forging, heat treatment, milling, drilling, profiling, turning, surface grinding, reaming, rifling, honing, thread milling, polishing, browning, spline milling, spring making, plating, filing, tapping, shaving, slotting, broaching, lapping, brazing, soldering, leather work, and all classes of wood operation. Naturally there are a great number and variety of machines in use. The selection of the most

suitable machines is not an easy problem especially if funds are limited, and a constant survey has to be kept on all new machines appearing on the market. Now that machine tools out here cost about £800 per ton this factor makes the selection more difficult. In many cases where funds are limited it may be better to buy more of the simpler and cheaper type of machines especially where there are short runs on component operations and the fixtures are being frequently changed.

Most operations on small arms are relatively light cuts. It is generally recognised that the setting up of the fixture for each operation is likely to produce some scrap, therefore as the volume of production of the article increases it means that more and more machines can be permanently set up for each operation and thus lessen the chances of scrap. We have on one particular weapon machines set up for each operation, and on another weapon where the volume is much smaller, each machine on an average is set up ten times for a production order of weapons. The greater the number and frequency of set ups the more difficult it becomes to keep machines operating at their fullest capacity. In some cases a set up may take hours, and this is lost productive time. It has been found difficult at times to keep machines producing 50% of their capacity owing to the frequent changes and set up. When estimating for a plant to produce a certain quantity of articles this factor must always be kept in mind, otherwise there are likely to be recriminations, when trying to secure production at a later period.

The securing of skilled setters up is one of our main problems. As this is a young country we have not had extensive engineering industries established for years, from which we can draw supplies of skilled labour, nor are there allied industries from which we could find skilled operative labour. Overseas, where families have had generations of training the position is more satisfactory. Our aim has been to manufacture our products with what is termed unskilled labour, and as this labour becomes familiar with various operation it is advanced to operations which carry a higher margin of skill. Being situated away in the country the class of labour available is either from the mining or the agricultural centres. We are fortunate in that we have an industry award governing the factory, and it includes all classes of work and trades so that we are not bothered much with lines of demarcation, or conflicting awards.

It is necessary to carry a large staff of skilled toolmakers to cope with our requirements, and there is little prospect of farming out the manufacture of simpler components as is practised overseas. It is only in the last few years that we have been able to have some cutters, fixtures, and simpler type of gauges made outside. It is pleasing to note the increase of toolmaking establishments that are coming into being, and we are now utilizing them as far as possible.

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We have found from long experience that it requires under normal conditions approximately, one toolmaker for every six operators to keep up with the supply of tools and to maintain the repairs of gauges, fixtures, etc. Where large numbers of unskilled labour are engaged the breakage of cutters, gauges, and fixtures rises rapidly, and the above ratio does not hold good.

As this class of work entails many drop forgings that have to be located in jigs and fixtures it is our practice to hold these to close limits to prevent wide variations which can cause much trouble in locating and machining. On the small and medium class of forgings these are usually held to a limit of .020 in. for thickness, although this may make the drop forgings slightly more costly it has been found to be a good investment.

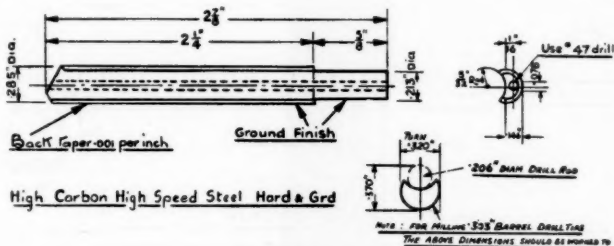


Fig. 3.—Barrel Drill.

With regard to the sharpening of cutting tools it has been proved that it is good practice for each section to have its own cutter sharpening machines, as it has been found that many machine tools have some peculiarities that necessitate some alteration to the cutter to produce work acceptable by the gauges. There are several machining operations peculiar to small arms manufacture, and some of these pertain to the manufacture of barrels. As previously mentioned the selection of suitable steel is most important and cannot be dismissed lightly. Often when the barrel has been forged, heat treated, centred, and rough turned it is ready for drilling. It is as well to point out that although the barrel at this stage is only rough turned it should run true, for any run out when revolving at some 2,000 revs. can cause trouble. The design of the barrel drilling machine is much the same the world over, in that it consists of a machine to revolve the barrel at a high speed and feed the stationary drill at a light feed with lubricant at high pressure being fed through the drill. Drills used may be a tungsten carbon steel, high speed steel, or tungsten carbide. The drill is usually of the form of a D bit with only one cutting edge. An oil hole runs through the drill and lubricant at high pressure is forced through this hole and both

lubricates the cutting edge and washes the chips back along the groove (Fig. 3). The drill is fastened usually by soldering or brazing to a tube of similar section. Owing to the large flow of lubricant high cutting speeds can be obtained. Our practice is to use special high speed drills and on 50 tons steel run them at a cutting speed of about 160 ft. per minute. As the drill with the tube is a frail tool only a light feed can be used and this is usually about .0005 in. per revolution. If conditions and material are good we find we can sometimes get about 80% of the drilled barrels with a true hole so that they do not require straightening after this operation.

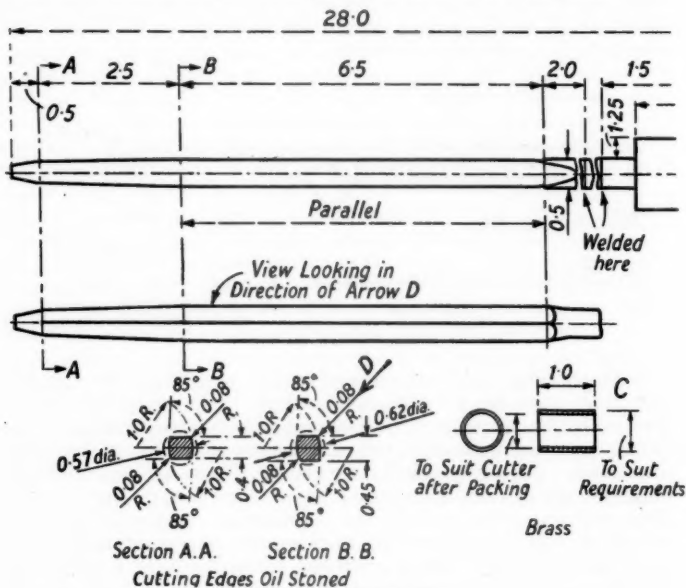


Fig. 4.—Barrel Reamer.

We have so far finished the bore of barrel to size by reaming and the practice is to pull the reamer through the barrel. It is the practice in some cases to finish the bore by spill boring or square reaming, an operation which appears to be peculiar to the rifle trade. Fig. 4 shows one type of square reamer. This operation produces a remarkably good finish. However, we hope in a few months to be in a position to hone the bores. From tests made it is expected to hone about  $1\frac{1}{2}/1000$ ths in. in two minutes. Fig. 5 shows a honing machine.

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Rifling is done before the final reaming and so far as we are concerned is performed by means of a hook cutter. It is the practice in some continental countries to use a scrape cutter and it is claimed that as the material becomes harder so the scrape cutter is superior.

Barrel straightening is an art and has no relation to any allied trade. With the rapid increase of production from peace time to war time, it is found that the requisite number of barrel setters are not available so that emergency steps have to be taken to train them. This position is I think common to all countries. Barrels are usually straightened either by hammering the barrel across two

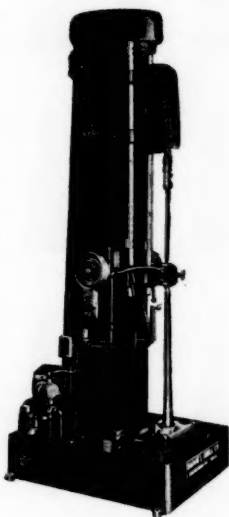


Fig. 5.—Honing Machine.

blocks of varying widths or by means of a screw press. To test whether the barrels are straight they are viewed for shade. This may either be by looking through the barrel against a shaded window or else holding the barrel on centres, where one centre carries a small coloured glass disc with a fine circle scribed on it. In the former process a shadow is thrown down the barrel to the middle. The shape of this shadow indicates the straightness as the barrel is revolved. Fig. 6 indicates the various shadows that may be seen in a barrel in various stages from being true to being badly bent. In the centre method a series of circles are seen and as the barrel is revolved the circles appear either concentric if true or eccentric if bent. This

latter method, however, only indicates the straightness at definite points, whereas the former method allows the whole length to be inspected. From tests carried out it has been ascertained that a bend of .0005 in. near the middle of the barrel can be detected by the shade method. It is hoped in a few months to have in operation

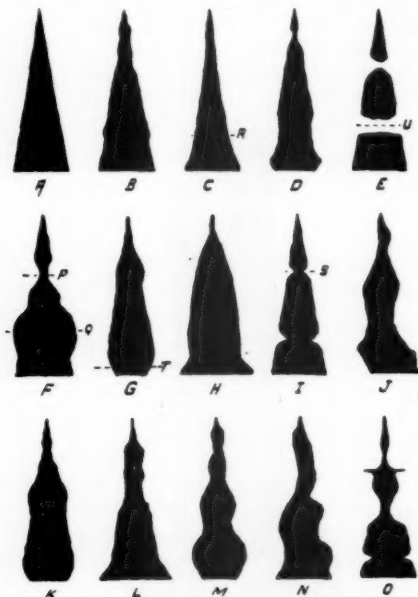


Fig. 6.—Shadows illustrating various Barrel Imperfections.

a method where with the use of an auto collimator the exact bends can be determined. Barrel setting is one process where, so far, a machine has not been invented to replace the human operation. It is considered in some quarters that the art of rifle making is rapidly dying out, and the training of a personnel to manufacture rifles on a large scale is a task of considerable magnitude.

In conclusion I wish to extend my thanks to the staff who have assisted me, also to the article on "Production Design of Ordnance" by J. D. Pederson in Army Ordnance.

## CENTRALISED GRINDING AND THE WAR

*By D. F. Galloway, Whit. Sc., B.Sc.*

This article suggests a rational application of centralised tool grinding as a practical aid to the successful dilution of labour, and the increase in production. The fundamentals of single point tool and twist drill grinding are mentioned, and the advantages of coolants are stressed.

**T**O meet the demands of the war the industries of Britain are being called upon to increase their productive capacities to the utmost. Every machine, every tool, every worker is needed to ensure success in the immense task that lies ahead, for machines, tools, and workers are the essential elements of all production units, from the gigantic arms factories to the small jobbing shops. However great the efforts of the Government and the industries concerned, many months must elapse before the supplies of machine tools, small tools, and labour are even comparable with the demands of ever increasing production. For this reason it is imperative to conserve our present resources by using them to their fullest extent under the most efficient conditions, and by the elimination of waste.

### Cutting Tools and Dilutees.

The pride of every skilled worker is his tools. The ability to select and prepare the correct tools is one of the chief distinctions between the skilled, semi-skilled, and unskilled workers. Since this ability is developed only by years of experience and practice, it is not surprising that the partially skilled man, who in this war emergency is asked to attempt skilled work, should approach the tool grinding problem with considerable intrepidity. If inexperienced men attempt to grind their own cutting tools, as skilled men do, the result will be an increase in the proportion of scrap work pieces and spoiled cutting tools, as well as a reduction in output, due to unnecessary time spent by the inexperienced operator trying to grind his tools satisfactorily.

The obvious solution is to have all tools required by these workers ground in a central tool grinding department or by an expert grinder. Operators must be forbidden to grind their dulled tools. This procedure presents no difficulties, for the variables which can enter into the process of grinding a given tool have been investigated scientifically, and there is no need to-day to believe that such factors as choice of wheels, angles of rake and clearance, etc., are matters of chance or of the seeming witchcraft of the skilled worker. Once the nature of the job to be produced is known, the selection of cutting

tools which will give economic removal of metal and leave the required surface finish, is easily achieved by reference to tool makers' charts. The problem of tool angles is one regarding which the greatest misgivings arise. Such misgivings are entirely unfounded for these angles are no longer a matter of conjecture. In U.S.A., Germany, and Britain research on cutting angles has resulted in fairly comprehensive tables, which give the appropriate angles for a given tool cutting a given material. Where tipped tools are used the makers' instructions regarding angles can usually be relied on. By reference to tables such as Fig. 1, it is possible to prescribe the precise angles to which a tool must be ground. The grinder simply sets the tool to the required angle and produces an ideal cutting tip free from the imperfections of the human element which mar the hand ground tools of individual workers.

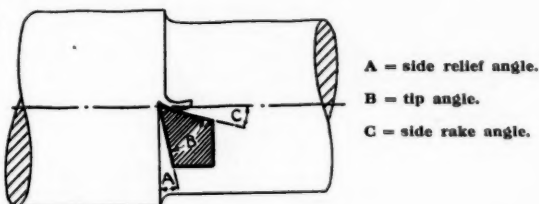
### **Advantages of Centralised Grinding.**

The idea of centralised tool grinding is not new, and its application even in tool rooms, etc., where a comparatively small number of workers are engaged has been shown to effect a great saving in time and material. The complex forms of many cutting tools such as milling cutters, etc., compel users to return them to a grinding department for regrinding. On the other hand the comparatively simple forms of single point cutting tools and twist drills have encouraged users to grind them by hand, and now the strong cords of tradition and convention are the chief factors which bind us to this undesirable procedure. Many tools have their cutting ability impaired and their cutting life considerably shortened by improper grinding which in addition to the introduction of incorrect cutting angles often results in burning, checking and cracking of tools.

If dulled tools are returned to the section grinder or to a centralised grinding department a steady flow can be maintained so that the working stock of tools in each department need not be so great. This is a distinct advantage in war time when supplies of machines and cutting tools fall below the requirements for the ever increasing production. Another advantage which must not be overlooked at this time, when there is a feverish speeding up of production, is that if tools of all workmen are accurately ground by an expert grinder it is easy to adopt more elaborate practices in tool preparation, such as lapping or honing the wearing surfaces of the tip. It would not be easy to provide equipment and to instruct each individual turner or shaper how to add these refinements which have such an important effect on the life and efficiency of the tools, but when all tool grinding is centralised the change is a comparatively simple matter. Moreover, when rough grinding, the possibilities of over heating and rapid cooling which result in cracking and finally in destruction of the tool by fracture, are reduced to a minimum.

**Rational Application of Centralised Grinding During War.**

The Packard company has set up a centralised grinding department exclusively for the grinding of cutting tools of all forms. Although this is an ideal solution to the problem, it may be advisable in the present emergency, when immediate output is of paramount importance, to carry the idea only so far as is possible before the inconvenience of the change-over outweighs the immediate gain. Each production engineer who contemplates this change over must consider it in relation to his particular plant, and in relation to the present short term policy. The gains and losses incurred by the

**Fig. 1.****PRINCIPAL ANGLES OF SINGLE POINT CUTTING TOOLS**

Material cut	Side relief angle $A^\circ \pm 1^\circ$	Tip angle $B^\circ \pm 3^\circ$	Side rake angle $C^\circ \pm 2^\circ$
Soft mild steel up to 30 tons/sq. in. approx.	7	66	17
Semi-hard steel, up to 45 tons/sq. in. approx.	6	72	12
Hard steel, over 45 tons sq. in. approx.	6	76	8
Brass (ordinary).	6	77	7
Bronze (ordinary)	6	78	6
Aluminium.	7	63	20
Copper.	7	58	25
Bakelite and most non metallics.	5	73	12
Cast iron (soft).	6	74	10
Cast iron (hard).	6	77	7

change-over must be carefully estimated. The results may show that the best policy is to centralise merely by establishing an expert grinder in the section where the tools are used, or by the addition of a new, or extension of an existing grinding shop, and the introduction of a system of collection and distribution of the tools.

### Single Point Tools.

An important factor in any scheme for centralised grinding is to have adequate machinery for grinding single point tools. Such grinding machines must be equipped with an arrangement such as a tilting table whereby tool tips can be ground with ease to specific angles. Another essential is the provision of gauges for the inspection of re-ground tools. This can be done by an adjustable square but it is desirable to have simple plate gauges incorporating those angles which occur frequently. The wheels required depend on the tools ground. The treatment of the ordinary carbon steel tools is well known. The grinding of cemented carbides requires a little more care and in order to produce the most efficient cutting tip three wheels are required. These are a coarse wheel for roughing and removal of the supporting shank, a fine soft wheel for finishing the top, and a diamond wheel for lapping the wearing surfaces of the tip. During the process of grinding there should either be a

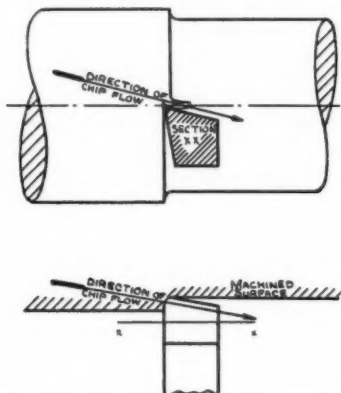


Fig. 2.—Finishing marks parallel to chip flow.

plentiful supply of water, or no water at all. Under no circumstances should the tool be subjected to sudden cooling by an intermittent or inadequate supply of water during grinding or by plunging into water immediately after grinding or when hot and taken from the machine before grinding.

However fine the finishing process on a tool tip, some minute ridges are bound to remain. These fine grooves should if possible be arranged parallel to the chip flow. (Fig. 2).

When grinding tipped tools it is desirable always to grind toward the tool shank. (Fig. 3).

### Twist Drills.

Almost everyone admits that the common twist drill is greatly abused but few do anything about it. Engineers who strive hard to get an odd percent on efficiency here and there, stand by without the slightest compunction while the majority of twist drills on their plant are so incorrectly ground that they function in a state of great inefficiency, often giving less than half the possible holes per grind, in addition to excessive power consumption, inaccurate holes, etc.

Common as the twist drill is, it must not be supposed that its design or mode of operation is simple. Near the periphery of the drill point the action is similar to simple cutting tools but near the the centre the metal is crushed. However great the r.p.m. of a drill

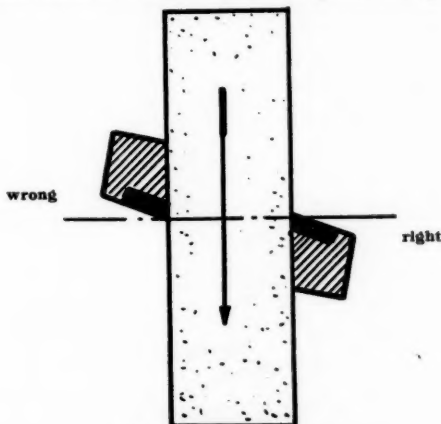


Fig. 3.—Grind toward shank.

the speed of the cutting edges reduces toward the centre or point of the drill, where it is zero. Moreover, the design of drills is such that this point cannot belong to both cutting edges, and in fact belongs to neither, but merely transmits to the material the feed thrust exerted by the drilling machine. This results in crushing. Although the common twist drill has to perform such a complicated task of simultaneous cutting and crushing, comparatively simple methods of grinding a suitable point have been developed.

Strict adherence to proper re-grinding is amply repaid by surprising increases in output per grind, accuracy of holes produced, and reduction of power consumption. Some important features of twist drills such as spiral angle, etc., are not altered when regrinding but the tip form is changed, and to obtain effective results the following elementary rules should be observed. (Fig. 4).

- (1) The length of both lips must be identical.
- (2) The clearance of angle of both lips must be identical.
- (3) The inclination of both lips to the axis must be identical.
- (4) Thinning of a drill point must be identical on both sides of the point.
- (5) Overheating of the drill point during regrinding must be avoided.

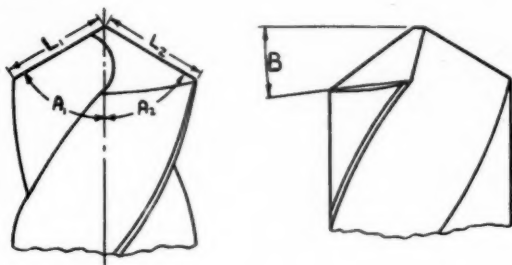
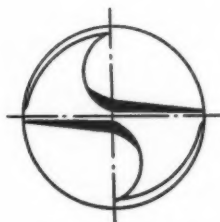


Fig. 4.

Length :  $L_1 = L_2$   
Angle :  $A_1 = A_2$   
(a)

Angle B same both sides,  
decreasing toward point.  
(b)



Thinning symmetrical.  
(c)

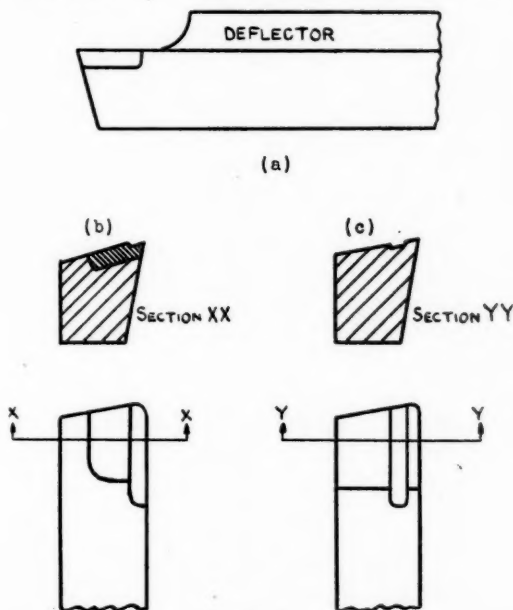
### Chip Breakers and Deflectors.

As cutting speeds are increased the problem of chip disposal becomes more acute. The process of disposal begins at the cutting tool itself, where the mere inclusion of a chip breaker or deflector brings the excess material under control as soon as it leaves the work-piece. Various forms of chip breakers and deflectors suitable for single point tools are shown in Fig. 5.

Large drilling chips can frequently be broken up by grinding the drill point in steps or by making a groove just above the inside face of the lip and parallel to the lip edge.

**Coolants and Cutting Tools.**

The immediate object of centralised grinding is the production of good cutting tools, but the ultimate object is the rapid, economic production of work pieces. A useful adjunct in the attainment of this object, and a vital factor in tool economy is the use of coolants including soluble oil, soda water, lard oil, mineral oil, paraffin, compressed air, etc. The appropriate use of these coolants as pres-

**Fig. 5.**

(a) Adjustable deflector. (b) Effective chip breaker. (c) Tool edge weakened by undesirable chip breaker.

cribed by the suppliers, permits considerable increases in cutting speeds, improves surface finish, and frequently doubles or trebles the tool life.

The desirability of keeping all small tools in good condition so that when called upon they operate with maximum efficiency cannot be emphasized too greatly at this time. It must always be remembered that the condition of the cutting tool is a vital factor in the overall efficiency of the machine tool as a production unit.

## PRODUCTION OF OIL ENGINE CASTINGS

*Discussion, Nottingham Section, on paper by Mr. R. C. Shepherd.*

*Note : The paper appeared in Vol. XVIII, page 445.*

**M**R. GIBBONS : Gentlemen. I am sure we have learnt a good deal, from Mr. Shepherd's lecture and that the author will be willing to answer your questions. The meeting is now open for discussion.

**MR. JOHNSON :** I am sure I am expressing everybody's point of view when I say we are very pleased to see Mr. Shepherd's fine arrangement of slides and to hear his methods described. To those who have had the opportunity of going round his foundry, I think it is an education in foundry practice.

I should like to know what sort of control Mr. Shepherd has on the runners and risers. Are they marked on the pattern.

We know all foundrymen like to put in as many chaplets as they think fit. Have you any method of controlling the number ? It is a difficult thing, and I have not known anybody who has managed to do it, but as you have taken so much trouble over the various minor points I should like to know what you have done.

I did not notice anything in the way of heat treatment of castings. Do you do this ? I presume if you do it is only castings that suffer from heat in the later part of their existence, and I should just like to know if you have any heat treatment of them.

**MR. SHEPHERD :** With regard to the location of runners and risers, wherever possible these are standardised in the pattern shop particularly with major castings and in all cases of pattern plates used in the mechanised foundry. In both these cases it is fairly easily achieved. Wherever else possible runners and risers are indicated on the pattern.

With regard to chaplets we have done a fair amount of work, and have been successful in cutting out the big ugly things which cause leaking troubles on pressure test. We also call for all chaplets to be pure tinned coated. We believe pure tinned chaplets to be more satisfactory than those coated with a mixture of tin and lead as we have had many cases where lead coated chaplets have given trouble.

Regarding the number of chaplets used, wherever possible we limit them, in many cases we indicate the position of each on the

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pattern, generally by means of a small protrusion on the pattern which leaves a slight depression in the mould. This particularly applies to small cylinder heads in the mechanised foundry and to other similar pressure tested jobs. It is difficult to prevent moulders using any bit of flat iron or steel plate they can get hold of, particularly on big jobs and as far as possible this is prohibited, but only by careful supervision can these details be controlled.

Regarding heat-treatment we do not actually do this in the foundry department and this is why I did not refer to the point in my paper. Certain castings are however heat treated elsewhere, mainly with the idea of relieving casting stresses and also to prevent growth during service. The property of growth in Cast Iron under fluctuating temperature conditions has been known for many years and seasoning of castings for weeks and even months was invariably resorted to. Now an annealing or normalising treatment at a temperature of about 600°C. is the usual practice. Careful measurements have been taken by our machine shops before and after this treatment and very appreciable growth has been found to have occurred during treatment. Such treatment does take up a large proportion of the initial growth of cast iron.

MR. LAWSON : I have listened very attentively and with great interest to Mr. Shepherd's lecture. I appreciate many of the difficulties which he encountered, and I give him full marks.

I should like to ask what percentage of moisture he allows in the sand for his mechanised section. Also he referred, I believe, to cast iron having a tensile of 30 tons. I presume he refers to alloyed or inoculated iron. And finally, has he had any experience of the automatic firing which is coming to the front so rapidly?

MR. SHEPHERD : The percentage of moisture in the sand in the mechanised foundry varies according to the season. In hot weather a little drying out is experienced. From the mill to the machines there is a fair distance for the sand to travel, and a little drying out has to be allowed for. Our moisture content varies from 5½% to 6½%. One hears of some foundries using a sand having a moisture content as low as 4%. This is due to the moisture content being largely controlled by the grain size of the sand :—the finer the sand the more moisture it needs. In other words a very fine sand with 4% moisture would be practically unworkable, whereas a coarser grained sand with 4% might be easily handled. It depends almost entirely upon the characteristics of the sand being used.

With regard to cast iron having 30 tons tensile strength it was either alloy or inoculated irons to which I was referring, but it is possible to obtain now anything up to 20 and 22 tons per square inch in straight cast irons. Certain statistics were recently presented to the Institution of Mechanical Engineers giving the results obtained by the British Cast Iron Research Association on mis-

cellaneous test pieces submitted hap-hazardly by the foundry trade. These results showed in several cases, unalloyed straight cast irons gave as much as 22 tons per square inch. This shows how much cast iron metallurgy has progressed. The use of alloys enable still further increased strengths to be obtained and also assists in keeping the grain size uniform in varying sections.

I have not had any actual experience of automatic firing in the foundry but I think there is a big future for it. I believe there are certain technical difficulties yet to be overcome in connection with foundry drying ovens. One drawback, I think, is that it is necessary to have a single unit to each oven. Where a battery of ovens operated from one firebox is involved, a high capital expenditure would be necessary to install automatic firing on each individual oven. But I do think there is a very big future for it particularly in view of possible savings in stoking labour, fuel and firebox maintenance, and also better efficiencies and temperature control.

MR. MITCHELL: I would like to say how much I appreciated Mr. Shepherd's paper.

I was a little disappointed he did not go further into the question of porosity caused by the difference in change of section of a casting and state whether he attributed the improvements obtained to metallurgical or founding method changes.

I notice he was using plaster patterns. Could he give us any idea of the life of a plaster pattern on a Vogel machine—a simple pattern with no intricacies about it.

MR. SHEPHERD: Mr. Mitchell has raised a very interesting point with regard to porosity, because porosity can be due to so many different causes. I think, however, I can say we have overcome the majority of our porosity troubles through metallurgical developments, i.e., mainly by the use of lower phosphorus irons and by controlling the carbon content and characteristics within limits. I am of that particular school of thought who believe that for the intricate changes of section existing in modern castings, the lower the phosphorus the greater is the immunity from porosity. Such irons are a little more expensive, but the extra cost need not be unreasonable providing raw material control is properly understood. It is definitely my experience that high phosphorus irons are entirely unsuitable for the type of casting referred to by Mr. Mitchell. The Drawing Office can considerably help the foundry department on the question of design and it has always been my experience that they will do everything possible to collaborate providing a concrete proposal is put forward, and that it does not affect any major points in design.

Regarding plaster patterns on Vogel machines, I am afraid my remarks were a little too broad here, and I welcome this opportunity of making them a little more clear. The life of an ordinary plaster on

## PRODUCTION OF OIL ENGINE CASTINGS

this machine would probably be about one day. I should have said that specific machines must be used in conjunction with plaster patterns. Actually we operate plasters on Jar Ram, Squeeze Turn Over Machines having jolting capacities of 300 lbs. On these machines we obtain a longer life with plasters than we did when they were handled by men on the floor. Most of the damage occurred by the plaster cracking at the edges through hand rapping and knocking with mallets, and ultimately loosening and splitting off altogether. The machine referred to by Mr. Mitchell however has a jolting capacity of 1000 lbs. and the resulting jar ram given is far too drastic and breaks the plaster in a very short time. Regarding the life expected we should expect a plaster to stand up to an order of 1,000 off providing it was well made and was not illtreated.

**MR. WILSON :** What is your practice in connection with smaller sized cylinder liners and what is your reaction towards the proposal of "loded" cast iron with higher Silicon contents ?

**MR. SHEPHERD :** For liners of that sort we use straight cast iron with a low carbon content and of course we work to a specification covering the other characteristics. Regarding foundry practice we have always obtained the best results by top running.

Some foundries bottom pour and get very good results, but top or bottom pouring depends entirely upon conditions. Bottom pouring for example requires a higher pouring temperature than top pouring. Rigid sand control is of the utmost importance in liner mould production. Not only should the facing sand used for the mould surfaces be of an excellent quality but also the sand used for making the runners should be given special attention. This sand must be capable of withstanding the washing and scouring action of all the metal entering the mould and sand inclusions in the finished machined liners can only be avoided by the most particular attention to this point. Actually we pay more attention and use a much better quality sand for runners than we do for the mould itself. Of course many of our smaller liners are centrifugally cast, but these are not made in our own foundry.

Regarding the metallurgical part of the question and "loded" liners, I assume you are referring to comparative wear. I am afraid I can't tell you much on this point, having had no practical experience of "loded" iron, but I have some idea of Mr. Young's theories regarding cylinder wear, and I believe to a great extent he is perfectly right. I am sure he is right when he talks about the complete absence of ferrite in the structure being beneficial and superior to an iron having free ferrite present. I am not sure what hardness loded iron has, but compared to Nitralloy cast iron having 1000 Brinell it is I believe comparatively normal.

**MR. GALE :** I should like to congratulate Mr. Shepherd on his

sympathetic attitude towards the Machine shops—that is rather unusual.

Has he ever been approached by the Drawing Office with a view to putting in small perches or lugs for locating purposes.

MR. SHEPHERD : The answer here is no. It is what we have always wanted but it seems to fall between three stools, the foundry, the machine shops and the drawing office. If location points were indicated on the drawing it would simplify matters considerably, but my experience has been that the machine shops either do not see the drawings before the first castings are made or haven't considered them from the point of view of locating spots until the castings are in the machine shops, and that seems to be most unfortunate part about it. It would be of very great help to both the foundry and the machine shops if methods of locating were decided upon before the pattern was made.

MR. RICHARDSON : From the drawing office point of view, I would say that this difficulty exists right from the beginning. Quite a number of draughtsmen have very little insight into the principles of moulding, and if firms could arrange for draughtsmen in training to see a little more into the foundry and see how the work is really done, then I think these draughtsmen would be able to make drawings with that insight. The question of location points comes under the jurisdiction of a Jig and Tool Department as much as the drawing office, and with proper co-ordination between the two, a fine drawing could be prepared which would meet all the required points.

I should like to ask Mr. Shepherd, if, when he spoke about positions on patterns being located for chaplets whether the foundry should do this, or whether the pattern shop should still indicate on the drawing.

MR. SHEPHERD : I think the best answer to your last question is that the foundry and the pattern shop are the same department, and it may be done in either section, but generally speaking the pattern shop would take instructions from the foundry with regard to locating points for chaplets etc.

With regard to the point about draughtsmen having foundry experience, I entirely agree. I think all draughtsmen, and in fact all engineers, ought to have foundry experience. It is the beginning of things, as far as our type of engineering goes at any rate, and it would be of the utmost value particularly to draughtsmen, but at the same time I don't think the experience gained in such a limited time would enable any draughtsman to indicate location spots and methods on the many varying designs involved. The responsibility for indicating these locations must rest between the foundry and the machine shops and the draughtsmen should then be instructed to indicate them on the drawing.

## PRODUCTION OF OIL ENGINE CASTINGS

In my remarks on the above point I have assumed that the machine shop management controls the Jig and Tool Drawing office. Obviously this latter department should function as indicated in collaboration with the machine shop superintendent, the foundry, and finally the design department.

MR. MITCHELL : With regard to bed castings weighing about 10 tons, what amount of sand would you think would be recoverable.

MR. SHEPHERD : It would depend upon how many cores are made in oil sand and how many in natural bonded sand. I should say about 70% to 80% of the oil sand used. If coke is not used for venting purposes the operation of cleaning the sand becomes a very simple matter and the yield would then be higher. Generally speaking 60% to 80% can be taken as a fair average of recovery.

MR. HOAD : I should like to say how very much I have appreciated the slides shown to-night.

Mr. Lawson has raised a point which was in my mind—the question of the tensiles. Apparently Mr. Shepherd can produce a better cast iron than we can obtain steel from the markets, which brings me to the point I was going to ask him. There is a firm known as the Mehanite Corporation of America. Has Mr. Shepherd any experience of controlling cast iron under the Meehanite process ?

Another point is whether, as a result of all this mechanisation, we could get some indication as to how the scrap percentage of a foundry under to-day's conditions compares with what it was like before mechanisation was introduced—I mean has it dropped from 10 to 2 or 8 to 5% or something like that ?

MR. SHEPHERD : Mr. Hoad referred to a higher tensile strength being obtained in cast iron than in steel castings. I am rather surprised to hear that, because steel metallurgy has progressed as has cast iron. I think it cannot be very good steel he is obtaining. Even the lower grades of steel castings call for tensiles of round about 30 tons per square inch. The figures I quoted however do show what remarkable progress has been made in the strength of cast iron.

Mehanite is an inoculated iron and is covered by various patents. I did not refer to it in particular but my general remarks on inoculated irons included this iron which is made by inoculation of cupola iron in the ladle by means of calcium silicide additions. Inoculation of cast iron is also done in other ways, but the Mehanite process covers the use of calcium silicide as an inoculant. Mehanite is a very good iron, I believe, although I have no actual experience of it. The claims for the iron are improved properties at a cheaper cost. I should say these claims depend largely upon the conditions involved. For example, in cases where little or no metallurgical control exists no doubt all the claims can be fully justified. The strength of inoculated irons can also be varied within wide limits

by alloy additions such as nickel, chromium, molybdenum, and copper.

The percentage of scrap is a question which exercises the minds of most people when considering mechanisation. Our own experience was a very high scrap figure for the first two months of operation. At times it was as high as 30 to 35%, but as we only had six production men working during this period we were not too concerned about it. We did not attempt to put the shop into full production until most of the troubles were overcome. But I can now say that our scrap is lower than it was under the old production conditions. Firstly, machine shop scrap, we reckon on a maximum of 5% but our actual figures are working out between  $3\frac{1}{2}$  and 4%. The overall figure, i.e., machine shop plus foundry scrap varies between 8 and 10%; 10% is the maximum figure and any scrap in excess of this calls for an immediate investigation. Scrap figures, however, are not always comparative as so much depends upon the standard of acceptance. We consider the standard insisted upon by our engineering shops to be very high.

The main point about mechanised foundry production is that production costs drop considerably and a precision job is obtained.

The meeting was closed with a vote of thanks to Mr. Shepherd.

## MANUFACTURING METHODS FOR PLASTIC MATERIALS

*Discussion, Southern Section, on paper by L. G. Chaffey*

*Note: The paper appeared in Vol. XVII. page 331.*

**M**R. DENNY (Section President): I feel sure that the subject that Mr. Chaffey has dealt with is one that the majority of us know very little about in the manufacturing sense, and personally, I have no questions to ask Mr. Chaffey in that way. With regard to the materials that are used in that type of manufacture, I would like Mr. Chaffey to give us a resumé on the physical properties of such materials. What are the particular jobs that they could be used for. If the design office or the production engineer thought of using such a material for a job, are there any special points that they would have to look to before they considered using it, such as whether it would weather and its dielectric properties and things of that kind?

**MR. CHAFFEY:** Speaking frankly, I am supposed to be a moulder not a moulding material manufacturer. The tendency of the trade is to say that the moulder sells his goods, but he has to have the backing of the material manufacturer all the time. Another paper has been read in the London district on moulding materials. The paper I have given is not particularly on the moulding materials themselves, although I might be in a position to answer a few questions on that point.

With regard to an engineer deciding whether he is going to make a job out of a die casting or a moulding or pressing, there are all those factors to be borne in mind that have been mentioned in the paper. Then the engineer would want to know whether it would fulfil his specification, and he would have to sum it all up. There are dozens of grades of materials to choose from and if anybody was seriously considering a moulding problem I would advise them to get in touch with a reputable moulder or a powder manufacturer and collect all the information that they could give on the properties of the materials.

The weathering of a job depends upon its water absorption figure. Some materials weathered particularly well from that angle, although they were, maybe, a little softer. For instance, the water

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absorption of ordinary wood-filled material was not good, but the water absorption of cellulose acetate was worse. (Mr. Chaffey illustrated this point by means of samples he had brought with him). A mineral filler was generally added in order to improve the water absorption figure, but that reduced mechanical strength, after a certain percentage. They were experimenting now, from the weathering angle, with a different type of wood filler.

Then there is the strength. Every material has a different strength and in the case of plastics each manufacturer has made materials and put them up and they will meet certain specifications. The only thing to do is to select the most suitable specification.

There is another factor—a problem as with bobbins where the maximum strength had to be obtained with a minimum weight. The maximum strength has to be obtained, but the material must not absorb water.

There are so many factors attached to this that it is difficult to answer a question as to what are the properties of the materials. With heat-resisting materials obviously asbestos is the filler that is used.

MR. DENNY: Are there any papers on the subject.

MR. CHAFFEY: Bakelite, Ltd. and other moulding material manufacturers publish research figures on all their materials. Bakelite, Ltd. have published an extensive brochure which they called "data sheets."

In the majority of cases the customer does not know exactly what he wants. Generally, all he knows is that he wants the material to be strong or he wants it to be water-resisting, etc.

MR. WIKNER: Are the curing temperatures of 300° and 340° mentioned, Centigrade or Fahrenheit.

MR. CHAFFEY: They are Fahrenheit.

MR. WIKNER: Is the sample you have with you done under pressure with a powder in the first place, or is it made from acetate sheet?

MR. CHAFFEY: It was made from powder.

MR. WIKNER: Was it done by injection?

MR. CHAFFEY: It was done by displacement as shown on the slides.

MR. PRATT: I congratulate Mr. Chaffey on being professionally engaged in a job which I think must be pleasing to his artistic sense. I consider that they are producing things of beauty in shape and also in colour. As far as engineers such as myself are concerned, as a rule all our products were dull grey or black, and I can see a possibility in the future, when moulding is applied on a large scale to our machines, when all workshops will become more attractive to the eye. One can imagine restrictions having to be placed on the draughtsman's imagination or taste, but I really think that

the materials are something that please the eye and that a beautiful shape and clean form, etc., are obtained by using them.

There is one feature that I would like to ask Mr. Chaffey about, which I do not think has been mentioned, and that is the question of reinforcement in the material. I believe that something is occasionally put in the nature of wire reinforcement—wire mesh or something of that sort.

MR. CHAFFEY : That is so.

MR. PRATT : There is one point in Mr. Chaffey's description of the heating which rather puzzles me. Mr. Chaffey has spoken of hot water heating and I believe he has said that the temperature has to go up to 300°. How do they get water up to that temperature ?

MR. CHAFFEY : The high temperature is obtained under pressure.

With regard to the colour business, I am afraid I am rather going to dash Mr. Pratt's hopes. We are trying to get out of the colour market ; industrially, it is a complete flop. The phenol materials, that is the material of which the majority of my samples are made, will gradually fade, in fact everything fades. The only future for moulding is in the industrial world. We are not interested in fancy goods, in fact some three years ago we commenced to cut out some thousands of pounds worth of moulds which had been put down on pretty looking stuff.

With regard to the hot water, that was, of course, kept under pressure all the time. Existing boilers could sometimes be converted to supply heat in that form. I went round Courtaulds' plant not long ago. They had just installed it and had found it a huge success ; they were making the bobbins for their silk spinning and had their own moulding shop, but they had to work to a much higher specification than I would like to, because owing to the duty they had to get their weights dead accurate.

With regard to reinforcement, all sorts of doges are used, but one has to bear the cost in mind all the time.

The meeting was closed with a vote of thanks to Mr. Chaffey.

## ERRATUM

On page 268 of the paper by Dr. G. Schlesinger "Substitute Materials in Time of War" (Vol. XIX, No. 7, July, 1940) second last line "oil grooves parallel to the axis of rotation" should be "oil grooves *vertical* to the axis of rotation."

## FREE LOAN OF ONE THOUSAND GUINEAS TO THE GOVERNMENT.

The Institution has loaned to the Government, free of interest, the sum of one thousand guineas, representing the surplus income over expenditure for its financial year ended June 30, 1940.

The following letter of acknowledgment from Sir E. Campbell has been received—

TREASURY CHAMBERS,  
WHITEHALL, S.W.

*August 19, 1940.*

DEAR SIR.

The Chancellor of the Exchequer is very grateful to you for your generous action in lending to the country, free of interest, the sum of £1,050.

Sir Kingsley Wood asks me to say how greatly he appreciates your contribution to the national effort.

He will have a certificate sent to you shortly entitling you to the repayment of the loan.

Yours faithfully,

E. CAMPBELL.

The General Secretary,  
The Institution of Production Engineers,  
36, Portman Square, London, W.1.

